Chapter 2
Avoided Losses and the Development Dividend of Resilience

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Abstract Global economic losses from natural disasters continue to increase. And yet investments in disaster risk management (DRM) are not universal, as they are traditionally seen as being in competition with other development and economic priorities, and the multitude of benefits of DRM investments are not traditionally accounted for in cost–benefit analyses. This chapter contributes to this discussion by highlighting the multiple benefits of DRM investments, focusing on both the avoided losses when a disaster occurs but also the impacts on economic development even before a disaster strikes. The main message is that as well as reducing losses when a disaster strikes, DRM investments can generate a second 'development' dividend of resilience through a shift of investment strategies and perhaps even an increase in investment value that could benefit the economy even before a disaster strikes. Providing evidence about the existence of both these dividends to policy-makers and investors can contribute to a narrative reconciling short- and long-term objectives, thereby improving the acceptability and feasibility of DRM investments.

Keywords Disaster risk management · Resilience · Development · Economic losses

2.1 Introduction

Global economic losses from natural disasters are increasing over time and in 2014 totalled $110 billion (Munich 2015). There have been repeated calls to do more to prevent disasters or minimise their consequences for affected populations.

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Investments in disaster risk management (DRM), however, have to compete with many other development and economic priorities, and economic analyses of the cost and benefits of disaster risk investments have been the focus of intense research and discussions.

This chapter discusses the benefits of DRM expenditures, particularly those that go beyond avoidance of losses of lives and assets through better risk management. We focus on developing the narrative and providing evidence for the first dividend (reducing economic losses) and on the second dividend (development) of the framework outlined in Chap. 1. Chapter 3 discusses benefits linked to the third dividend (on co-benefits). Our main message is that DRM investments can also reduce indirect losses when a disaster strikes, and can lead to a shift of investment strategies and potentially an increase in investment value that could benefit the economy even before or in the absence of a disasters. However, at present, these "benefits" of DRM are understated and often not included in cost–benefit assessments. Providing evidence on the existence of these dividends to policy-makers and investors can help generate a narrative reconciling short- and long-term objectives, thereby improving the acceptability and feasibility of DRM investments.

2.2 Higher Disaster Losses at the Macro Level

Total economic losses from a disaster can be much larger than the face value of what is affected (asset damages), and the so-called "ripple effect" means its impacts extend beyond the directly affected population and infrastructure. For instance, certain economic sectors or segments of the population not hit by a storm can experience less income because of lower demand. These indirect impacts can affect long-term prospects of economic growth and development both in the geographic area in which the shock occurred but also elsewhere, according to the level and scale of economic integration. Accounting for and including these indirect losses in a DRM cost–benefit analysis is often challenging as a result of a shortage of data. It also requires recognition of certain moderating factors that determine how strong these indirect impacts are (Table 2.2).

2.2.1 Indirect Losses from the Disruption of Economic Infrastructure and Activity

Disasters are "macro" events as they can affect all economic actors in the area where they occur—households, government agencies and firms—even those that do not experience any material or human losses. Smith and McCarty (2009), investigating the impact of the 2004 hurricane season in Florida on household displacement, found that among the 21 % of households forced to move out of their home

Table 2.1 Reason for business closure following the 1994 Northridge earthquake

Reason	% of firms reporting	Local (L) or indirect (I)
Needed to clean up damage	*65.2*	*Local*
Loss of electricity	58.7	Indirect
Employees unable to get to work	56.4	Indirect
Loss of telephones	49.8	Indirect
Damage to owner or manager's home	44.4	Indirect
Few or no customers	39.9	Indirect
Building needed structural assessment	*31.5*	*Local*
Could not deliver products or services	24.0	Indirect
Loss of machinery or office equipment	*23.7*	*Local*
Building needed repair	*23.4*	*Local*
Loss of inventory or stock	*21.9*	*Local*
Loss of water	18.2	Indirect
Could not get supplies or materials	14.9	Indirect
Building declared unsafe	*10.1*	*Local*
Could not afford to pay employees	*9.5*	*Local*
Loss of natural gas	8.7	Indirect
Loss of sewer or waste water	5.3	Indirect
Other	15.8	Both

Note Reasons linked to local damages to the business are highlighted in italics; others are indirect reasons, owing to perturbations in infrastructure services such as transport or electricity
Source Tierney (1997)

after a disaster, 50 % had to do so because of the loss of utilities (e.g. no running water). Only 37 % had to move because of structural damage to their house.

Tierney (1997) found that the loss of utility services and transport following the 1994 Northridge earthquake in Los Angeles, California, had a heavy impact on firms. According to her, 65 % of the small businesses investigated closed after the earthquake because of the need to clean up damages. The five other most important reasons, mentioned by 59–40 % of the sample, included loss of electricity, employees' inability to get to work, loss of telephones, damage to owner's home and reduction in demand, with few or no customers (Table 2.1). Such issues are not related to direct structural damages to the business itself but to off-site impacts.

Business activity does not occur in isolation. Businesses are often integrated in a value chain and depend on upstream and downstream activities and stakeholders. Therefore, owing to complex economic intricacies, business output losses can be the consequence of a shock to the economic activity both upstream (backward) and downstream (forward), and the creation of bottlenecks within supply chains.[1]

[1]These ripple effects can even take place within a factory, if one segment of the production process is impossible and therefore interrupts the entire production.

According to the position of the bottleneck in the value chain, ripple effects can be backward or forward:

- *Backward ripple effects* arise when a shock propagates from clients to suppliers. For example, if the production of a client is incapacitated, input demand to its suppliers will also reduce. For suppliers sales will reduce, despite the absence of direct damages to its production capacity.
- *Forward ripple effects* arise when the impact propagates from suppliers to clients, for example when a client is open for operation but its supplier is unable to produce or sell inputs needed for production processes.

The output losses from a disaster depend on firm-to-firm network characteristics such as average number of suppliers, degree of complementarity and shape and structure of connections between firms (Henriet et al. 2011). Modern organisation of production, characterised by international production networks,[2] a limited number of suppliers, small stocks and production on demand, has created new forms of vulnerabilities to natural disasters, well beyond domestic economy frontiers. The impact of disasters on global value chains was illustrated by the Tohoku-Pacific earthquake in Japan in March 2011, and its consequences for domestic industrial production and the resulting decrease in exports of goods used as inputs, for instance in the auto industry. *The Economic Times*, an Indian newspaper, reported that, "Japan's Toyota Motor will cut production at its Indian subsidiary by up to 70 % between April 25 and June 4 due to disruption of supplies" (The Economic Times 2011).

If an economy's capital stock consists of a bundle of complementary assets, the destruction of one component reduces the overall productivity of the entire production system with an indirect impact much larger than what could be expected from the analysis of one destroyed component only. One relatively straightforward example illustrating the difference between direct and indirect losses is given by the case of two cities connected by a single road. Destruction of only a segment of this road is enough to disrupt freight connections between those two cities. The loss resulting from the destruction of one segment can therefore not be estimated based on the value of this segment, but requires an analysis of the entire production system depending on the connection between the two cities. The same is true—to some degree—for the entire economic system: the loss of one asset will have repercussions for others that depend on it.

Past disasters provide useful examples. The San Francisco–Oakland Bay Bridge, essential to both cities' economic activity, was closed for one month after the 1989 Loma Prieta earthquake (Fig. 2.1). This closure affected almost all small and large business in the Bay Area (Kroll et al. 1991) and, although it was difficult to quantify losses in economic activity, the scale of output losses was an order of magnitude higher than the amount needed to repair the bridge. The health care system in New

[2]We alternatively use the expressions "international production networks" and "global value chains".

Fig. 2.1 The Oakland–San Francisco Bay Bridge, which was closed for one month following the 1989 Loma Prieta earthquake. *Source* Dan Bluestein, Wikimedia Commons

Orleans is another example. Beyond the immediate economic value of the service it provides, a functioning health care system creates positive externalities, acting for example as a pull factor attracting workers to the region. After Katrina's landfall in 2005, the health care system experienced significant disruption and did not recover quickly (Hallegatte 2008; Rudowitz et al. 2006). Poor health care services made it more difficult to attract construction workers to the region (indeed, construction is a high-risk occupation), slowing down the reconstruction process. As a consequence, the disruption of health care services in the hurricane and its aftermaths went beyond the loss of its asset value.

It is important to note that not all indirect impacts are negative. Disasters reduce production capacity, but also increase demand for outputs from the reconstruction sector. Thus, reconstruction can act as a stimulus. However, the resulting dynamic depends on pre-existing economic conditions, such as the phase of the business cycle and the existence of distortions that lead to under-utilisation of production capacities (Hallegatte and Ghil 2008). If the economy is efficient and in a phase of high growth, in which all resources are fully used, the net effect of a stimulus will be negative, for instance through diverted resources, production capacity scarcity and accelerated inflation. If the pre-disaster economy is depressed, however, the stimulus effect may in some cases (e.g. when there are substantial aid flows) yield benefits to the economy by mobilising idle capacities.

For instance, in 1992, when Hurricane Andrew hit south Florida, the region's economy was sluggish, with 50 % unemployment among construction workers (West and Lenze 1994). Reconstruction had a large stimulus effect in the economy, which would have been impossible in a better economic situation such as the one in 2004, when four hurricanes hit Florida during a housing construction boom (ibid.).

Finally, old and low-quality construction is generally more vulnerable to damages than more recent capital. In the case of a disaster, the destruction of low-quality assets may allow the possibility of "building back better", improving the situation post-disaster. For instance, an earthquake may destroy old, low-quality, buildings, making it possible to rebuild with improved building norms. For example, after the Christchurch earthquake in New Zealand in 2011, building norms for energy efficiency led to better comfort and lower energy bills (Miles et al. 2014). However, experiences from the reconstruction process in Haiti after the 2010 earthquake found building back better may be much more difficult in practice, owing to a lack of adequate funding and technical expertise and raw materials in the disaster location (Kijewski-Correa and Taflanidis 2011).

2.2.2 Impact on Long-Term Growth and Development

Natural disasters have economic impacts, which extend beyond the short and medium run and affect long-run growth. Reconstruction indirectly affects the economy by crowding out consumption and investment. Post-disaster, uninsured households divert consumption towards reconstruction or draw down savings, potentially reducing the availability of investments in the economy (Hallegatte 2014). The same is true for firms, which have to divert investments and profit redistribution to households towards reconstruction spending. This effect can have a broad, economy-wide depressing impact. Ranger et al. (2011) find that the total indirect effect to the economy from the 2005 floods in Mumbai, India, would have been halved (reduced by $200 million) if all losses had been paid through insurance instead of letting households use their savings and firms their own resources, as occurred.

While such diversion can potentially have a negative effect on the economy, so can a lengthy reconstruction process, which depends on the degree and capacity to divert funds away from investments and consumption. While the €10 billion spent on reconstruction expenditure following the 2002 floods in Germany corresponds only to the equivalent amount of investments spent over 10 days in the country, reconstruction was spread out over more than three years, suggesting only a small fraction of investments can be dedicated towards reconstruction.

Therefore, reconstruction processes might become lengthier than expected, as consumers, insurance and reinsurance companies, firms and public organisations need time to direct large amounts of money to reconstruction, a constraint especially stringent in developing economies that are already lacking financial service infrastructure and lagging behind in investment capacity (Benson and Clay 2004).

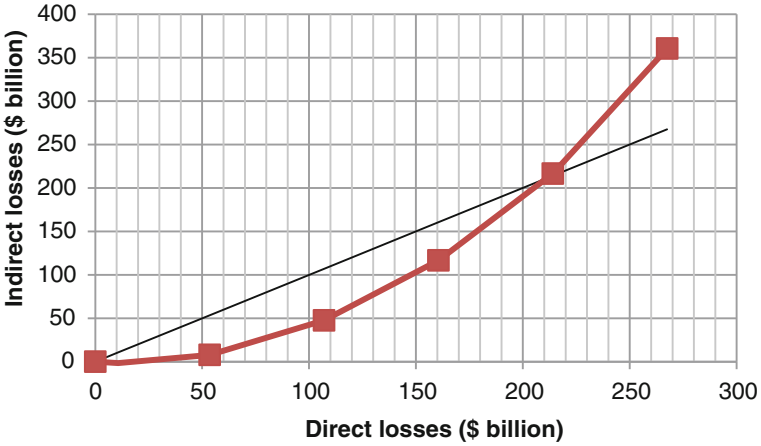

Fig. 2.2 Indirect (output) losses as a function of direct (asset) losses in Louisiana for Katrina-like disasters of increasing magnitude. *Note* The *red curve* signifies indirect losses. *Source* Hallegatte (2008)

Another source of friction is the reconstruction sector's capacity to absorb the increase in demand following a disaster: skill availability and organisational capacities are adapted to the normal state of affairs and are not always able to face huge increases in demand. One illustration of this issue relates to the long reconstruction periods that followed the French storms in 1999 and the AZF factory explosion in Toulouse in 2001, owing to as shortage of roofers and glaziers.

Therefore, the extent of indirect losses owing to the destruction of productive assets and infrastructure in terms of economic activity and growth does not depend only on the physical intensity of the natural event but also on the coping capacity of the affected human system and its ability to rebuild rapidly and efficiently. While investment spillovers are not an asset "loss", in the absence of tools to better manage risk and reallocate resources post-disaster economic losses are certainly higher.

Hallegatte (2008) models the direct and indirect losses from Katrina-like disasters in Louisiana. A non-linear relationship emerges: when direct losses are less than $50 billion, reconstruction is rapid and aggregated indirect losses stay close to zero.[3] Beyond $50 billion of direct losses, the reconstruction period extends over several years and indirect losses increase exponentially. When direct losses exceed $200 billion, total losses are twice as large as direct losses (Fig. 2.2).

Such non-linear relationships lead to large and long-term reductions in growth and lost output and may lead potentially to macro-level poverty traps, with entire regions falling into a vicious circle, leading the economy toward a lower growth equilibrium and reducing development capacity (Hallegatte et al. 2007). Such

[3]Note the aggregation hides important disparities among sectors and social categories.

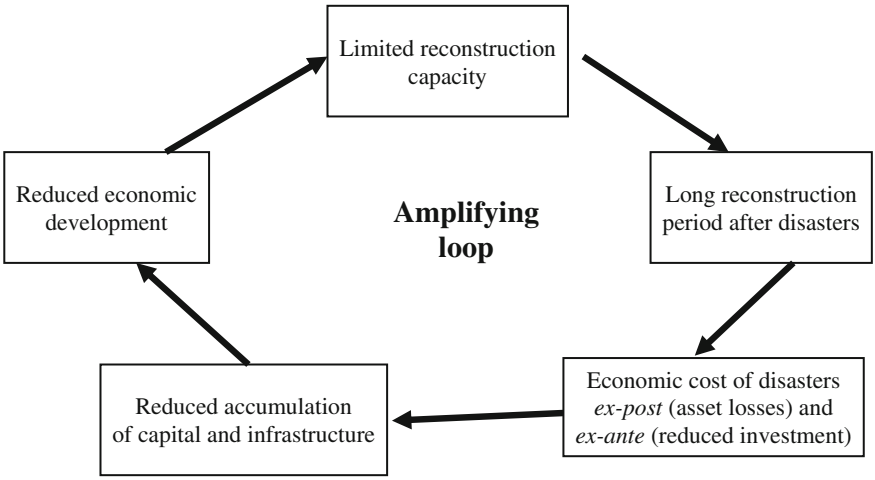

Fig. 2.3 Amplifying feedback loop that illustrates how natural disasters could potentially become responsible for macro-level poverty traps

poverty traps can be explained by amplifying feedbacks, as presented in Fig. 2.3. Many regions have limited capacity to rebuild after a disaster. If the region is regularly affected, it may not have enough time and resources to rebuild its asset base between two events. As a result, it may end up in a permanent state of reconstruction, allocating resources to rebuild rather than investing in new additional infrastructure and equipment, preventing capital accumulation and infrastructure development. Such a cycle, in the absence of external intervention, can lead to permanent disaster-related underdevelopment.

Over the long run, the effect on economic growth is a balance between negative and positive spillovers. The analysis of this shows ambivalent results, suggesting disasters have differential macroeconomic impacts, determined by a variety of factors, such as the absorptive capacity of an economy and its access to international capital including aid due, as well as the scale of a disaster (For contributions to the discourse, see Albala-Bertrand 1993; Felbermayr and Gröschl 2014; Strobl 2010; also Chap. 4).

Through interruptions of infrastructure and baseline services, propagations in the supply chain and diversion of spending by households and firms towards reconstruction, disaster losses go well beyond the direct asset destruction and affect the overall macroeconomics dynamics. These indirect effects, and what moderates them, are summarised in Table 2.2. Furthermore, the most recent literature on the impact of disasters on growth suggests that, while small disasters may not have long-term macroeconomic consequences, large ones are likely to have measurable long-term negative effects on economic growth (Felbermayr and Gröschl 2014; Hsiang and Jina 2014; Loayza et al. 2012).

Table 2.2 Summary of the indirect effects of natural disasters at the macroeconomic scale

Type of indirect effect	Moderated by
Losses in electricity and transport	Infrastructure quality and reliability
Supply chain ripple effects	Complementarity and size of shock
Crowding out investment	Level of insurance penetration
Stimulus	Existing economic situation
Capital replacement	Type of capital replacement

2.3 Welfare Losses at the Microeconomic Level

The previous section that focusing the evaluation of macroeconomic losses from a disaster on direct losses can be misleading and leads to underestimating the welfare impact. But underestimation of the welfare impact can also arise from disregarding the distributional impacts of disasters. For instance, it seems rather intuitive to think that the impacts of disasters on the livelihoods of poor and marginalised people are more substantial, first because of their higher exposure to physical risks but also because of the reliance of their livelihood strategy on fewer and more vulnerable assets. While the impact of the disaster can be disastrous for such people, the repercussions for gross domestic product can be invisible, especially if the very poor own close to nothing.

Thus, to more precisely examine the impacts of a disaster at the micro level, it is important to examine who is affected and how. Below, we examine first how asset losses are distributed among the population and then how asset losses translate into welfare losses.

2.3.1 Asset Losses Differ Depending on Who Is Hit

Here we examine how asset losses at the microeconomic level are determined and distributed. Asset losses are a function of the hazard, exposure and vulnerability. While a hazard is not determined by socioeconomic characteristics, exposure and vulnerability are.

One major determinant of asset losses is poverty status. First, poor people may be more exposed to natural disasters owing to the role of formal and informal land markets: if natural risks are included in land price valuation (or desirability), poor households should be more likely to live in risky areas where land is cheaper (Fay 2005). This explains why slums are typically located in floodplains or in areas at risk of mudslides, and why poor people are approximately 70 % more likely to be exposed to disasters in cities such as Mumbai (see more in Sect. 2.4) (Patankar 2015). But this may not always be the case. Risky locations may attract richer people: coastal cities are often highly exposed to flood risk, but they host households that are generally richer than those from rural and inland regions, because of

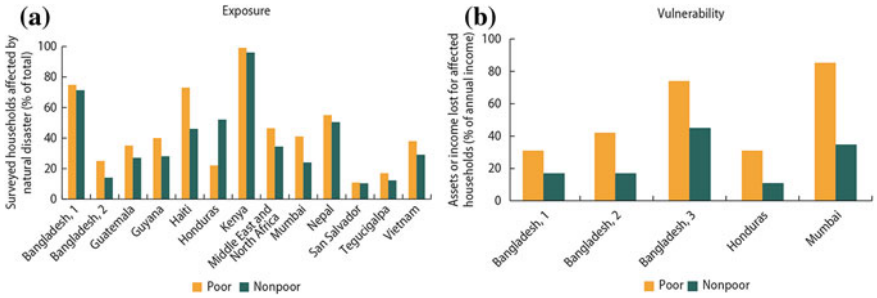

Fig. 2.4 Poverty exposure bias and poverty vulnerability bias exhibited in prior case studies of disaster contexts. *Source* See sources in Hallegatte et al. (2016)

sunny weather and amenities. For instance, Carter et al. (2007) found that Hurricane Mitch in Honduras in 1998 affected only 22 % of households in the poorest quintile, compared with 68 % in the richest quintile. Hallegatte et al. (2016) review case studies of post-disaster contexts examining exposure of poor and non-poor people (see Fig. 2.4 panel a).

While the evidence on poverty exposure to disasters is scale- and context-dependent, it is generally well observed that, when hit, poor people lose more in relative terms. This "vulnerability bias" owes to poor people having lower-quality assets, of which a larger portion are in material form and thus more vulnerable to disasters. For instance, while Carter et al. (2007) found poor people did not have higher exposure to Hurricane Mitch, they were nonetheless more vulnerable in relative terms: poor people lost 31 % of their assets and the rich only 8 %. Hallegatte et al. (2016) review case studies of post-disaster contexts examining the vulnerability of poor and non-poor people (Fig. 2.4 panel b).

The above studies suggest poor people are often more exposed to disasters, and, when hit, lose more. The welfare impacts of disasters can be underestimated by aggregate loss figures, since the value of the assets of poor people are too small to appear in aggregate figures. Therefore, aggregated or averaged asset or output losses do not appear as a metric able to capture the full complexity of disaster outcomes. Instead, welfare losses may be a more appropriate metric. But how to calculate welfare losses from asset losses?

2.3.2 Welfare Losses Are Different from Asset Losses

Taking asset losses as a starting point, two additional areas need to be assessed to estimate welfare impacts: (1) how asset losses translate into income losses and (2) the coping capacity and social protection offered at the individual and government level. Figure 2.5 shows the chain from hazard to welfare impacts.

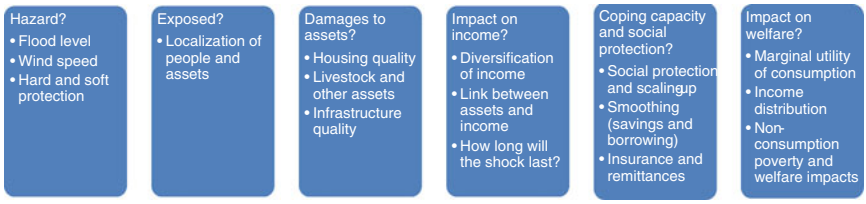

Fig. 2.5 The chain from a natural hazard to its impacts on welfare. *Source* Hallegatte et al. (2015)

The impact of asset damage on income depends on three parameters. The first is related to the reconstruction duration, as described in Sect. 2.2. The second is the link between assets and income (productivity) and the third is the diversification of income.

Estimating how asset losses translate into income losses is difficult to determine. According to the linkages presented in Sect. 2.2, the effect of a disaster on a household's income strategy depends on employment in firms nearby, and, in the case of self-employment, changes in demand for goods. For example, after the 2011 floods in Bangkok, Thailand, Noy and Patel (2014) quantified the direct and spillover effects on income. Households that were directly affected lost on average THB 7600 (approximately $220) in income; households not directly affected by the flood lost almost as much as a result of the reduction in demand or business interruption and ripple effects: THB 6700.

A third component that moderates or magnifies the impact of asset loss on income loss is the diversification of income, including from transfers such as pensions, social protection and remittances. The impact on households' income of the loss of local activities can be smoothed from income sources less affected by a disaster. In particular, government transfers such as pensions and social protection are diversified at the country level, and if a disaster affects only a small part of the country, transfers be only slightly reduced.[4]

Given impacts on income after the disaster, access to private and public coping strategies can reduce the welfare impact of an income loss.

Strategies include private financial mechanisms as well as government targeted interventions and, more generally, social protection. Government transfers can be made available for a period of time after the disaster occurs to allow households to recover from the shock. After the 2005 floods in Mumbai, households received compensation from the government amounting to on average 10 % of household asset losses (Patankar and Patwardhan 2014). However, the compensation scheme did not appear to target poor people or those who lost the most [as was also found

[4]This is true in large countries. However, in small islands, where disasters affect almost all of the population, risk-sharing through diversification may not be an option.

after the 2011 flood in Thailand (Noy and Patel 2014)]. More generally, a socioeconomic environment with a subsidised health care system and opportunities for employment can reduce welfare losses.

Financial inclusion can also help. Savings accounts and insurance can smooth the impact of a shock over time. However, although access to finance is slowly improving globally (van Oudheusden et al. 2015), in most developing countries the ability for poor households to access such services remains limited. More generally in reconstruction contexts, the experience after Cyclone Nargis in Myanmar in 2008 suggests high borrowing rates cripple the speed of recovery (World Bank 2015a).

In an environment with no or little access to social protection and smoothing mechanisms, a shock can potentially lead to poverty traps, especially for asset-poor households. Empirical evidence suggests poor households may liquidate assets in order to cope with shocks and smooth consumption. If the liquidation of assets is insufficient or if shocks are too frequent to rebuild an asset base, households can fall into persistent poverty (Krishna 2006). However, it is also shown that extremely poor households might on the contrary choose to smooth assets rather than consumption (Carter et al. 2007). These households choose to forego consumption rather than further liquidating limited assets in the hope of avoiding poverty traps in the current generation (if their asset base becomes too low, the household may be permanently stuck in poverty). But evidence suggests that such strategies may result in intergenerational poverty traps, as reduced consumption leads to health and educational deficiencies that have impacts on the human capital of children.

Evidence suggests acute impacts on health from lower post-disaster consumption, especially after droughts. Following weather shocks in Sub-Saharan Africa, asset-poor households feed children with less or lower-quality nutrition food, with studies tracking children over decades showing that these behaviours lead to stunting (Alderman et al. 2006; Dercon and Porter 2014; Hoddinott 2006).

Another impact of lower-post disaster consumption on children's human capital occurs through education. Dercon and Porter (2014) found those younger than 36 months at the apex of the famine were less likely to have completed primary school, and estimated the impact to be equivalent to 3 % income losses per year. Intergenerational impacts may endure: recent research in Uganda suggests educated household heads are much less likely to choose coping strategies that involve taking their children out of school (Helgeson et al. 2013).

Investments in DRM before and after a disaster hits can help people manage risks and reduce the welfare impacts of a natural disaster. Better land-use planning and improved building norms can reduce the exposure and vulnerability of the population, and poor people in particular. For instance, land titling in Tanzania is associated with increased housing investments, which reduces vulnerability to floods (Hallegatte et al. 2016). Improved financial inclusion *ex-ante* and favourable financing *ex-post* can hasten recovery and reconstruction. Universal health care insurance and scaled up social protection, for instance through cash transfers, can help avoid detrimental coping strategies taken by households and mitigate shocks. For instance, when droughts in Ethiopia caused food shortages and famine in 2011,

the Productive Safety Net Programme expanded its coverage from 6.5 to 9.6 million people in two months and increased the duration of benefits from six to nine months per year (Johnson and Bowen forthcoming).

The take-away from Sects. 2.2 to 2.3 is that, at the macro and micro level, direct asset losses do not tell the whole story. While the impact of a disaster might not be extensive at the macro level, without DRM investments welfare losses can still be substantial for parts of the population, especially poor people.

2.4 Slower Development in the Absence of DRM Investments

In addition to the loss-centric first resilience dividend, there are further benefits of DRM that arise even in the absence of disaster. This can be in the context of taking "natural" risks when disaster risks are well managed, as well as releasing suppressed economic potential in risky areas.

2.4.1 Development and the Exposure to Natural Hazards

Taking risks is sometimes an unavoidable (or desirable) consequence of development and economic growth. Investing in risky areas can be a conscious and well-informed choice, justified by economic benefits. For instance, increased exposure to natural hazards can be an unavoidable side-effect of investments to create additional employment and growth from international trade in areas characterised by low transportation costs but exposed to flood risks (e.g. Gallup et al. 1998). In China, for instance, Fleisher and Chen (1997) find that Total Factor Productivity (TFP) is 85 % higher in coastal regions than inland, and that TFP growth is not significantly different in spite of higher investment in inland regions, suggesting a permanent productivity advantage in coastal regions from lower transport costs. Cheap waterway transport attracts industrial production close to floodplains, and partly explains why most large cities are located on rivers. In coastal areas, increased exposure to flood can therefore be a deliberate trade-off against higher productivity and economic growth.

The same thing may happen in cities. The drivers of economic growth are concentrated in cities, and productivity growth is larger in cities in part because of positive agglomeration and concentration externality. Ciccone (2002), Lall and Deichmann (2012) and World Bank (2008) report urban–rural income ratios between 1.5 for developed countries and up to 3 for developing countries, suggesting higher productivity in cities at all stages of development. And not only are productivity and consumption higher in urban areas, but also amenities and infrastructure services are often superior: among low-income countries with urban

population shares of less than 25 %, access to water and sanitation in towns and cities is around 25 % points higher than it is in rural areas (World Bank 2008). These differences create strong incentives for rapid rural–urban migration. Confronted with land scarcity and high land costs in large cities, this migration has led to construction in at-risk areas (Burby et al. 2001, 2006; Lall and Deichmann 2012). In the most marginal and risky locations, informal settlements and slums are often present, putting poor and vulnerable populations in a situation of extreme risk (Ranger et al. 2011).

An illustrative example of poor people settling in risky areas is Mumbai, which is prone to high flood risk. Patankar (2015) reports on a survey of poor households living in Mumbai's flood areas and shows poor people are well aware of this risk, and are making a deliberate decision to live there to benefit from higher-wage jobs, better schools and medical care and existing social networks. Similar findings are found in Ho Chi Minh City, Vietnam (World Bank and Australian AID 2014).

Risk-taking can also increase welfare through environmental amenities (e.g. from sea views) and generate revenues from tourism. As of 2012, in the Bahamas, Cape Verde, Dominica, Grenada, Macao, Maldives, Montenegro, Samoa, São Tomé & Príncipe, St Lucia, St Vincent and the Grenadines and Vanuatu, tourism accounted for more than half of total exports (World Bank 2015b). Most of these countries are island nations exposed to natural risk (mostly hurricanes and sea level rise), yet expenditures from overseas visitors play a large role in economic output and can hardly be realised without increasing risk.

In situations where there is a trade-off between exposure to natural hazards and productivity or economic growth, improved risk management and more resilient development can mitigate this and accelerate growth and improved productivity (Hallegatte 2014).

This issue relates to the opportunity costs of *ex-ante* risk management, both by households and by lenders. Uninsured risk exposure as well subjective perception endogenously change behaviours, and thus the conditional expected wealth creation dynamics. Failures in financial markets and risk aversion mean the risk of weather-related shocks, including disasters, influences household choices of livelihood strategies in order to minimise the consequences of a shock. Households trade off expected gains for the reduced risk of suffering catastrophic losses.

Such livelihood strategies often entail diversification of activities and less productive investments, constraining productivity and wealth accumulation: households undertake costly behaviours as a means of reducing their exposure to uninsured risk, resulting in forgone welfare gains. Taking into account the prospective consequences of shocks, poor households may manage risk exposure by selecting low-risk, low-return asset and activity portfolios that reduce the risk of greater suffering but limit growth potential and investment incentives (Rosenzweig and Stark 1989). This for instance discourages adoption of new technologies and decreases incentives to invest in productive capital accumulation.

Elbers et al. (2007) provide an illustration of this effect in an agricultural context in Zimbabwe. They found that farmers exposed to risk exhibited a mean capital stock half as large as that for farmers who were not exposed. Of this reduction in

capital, *ex-ante* risk accounts for two thirds of the difference. In this case, therefore, most of the welfare impact of risk is through reduced investments and risk-taking, not through damages and losses when the hazard does materialise into an actual event.

2.4.2 Lower Risk-Taking Owing to "Background Risk"

Households and firms face a wide variety of potential shocks that they have to manage together. As an illustration, the 2014 World Development Report (World Bank 2013) reports the frequency of occurrence of a variety shocks, from loss of job to health and floods, in a number of developing countries (Table 2.3). In most countries surveyed, a large proportion of rural households reported being affected by two or more shocks, with drought and flood predominant.

Importantly, the evidence suggests households consider their vulnerability to natural risks like floods and droughts when making other risk-related decisions in other domains—such as creating a business or migrating to a city. Because these risks interact, the existence of natural risk can reduce the willingness to take these other risks, which are necessary for development and growth. Empirical evidence on innovation and entrepreneurship suggests, for instance, that increased risk-taking behaviours are associated with higher economic growth and development:

- The contribution of risk-taking (e.g. through increased innovation/entrepreneurship) to economic growth is well established in the economic literature and was grounded on the theory of endogenous technical change (Romer 1990). The empirical evidence that has followed has largely supported the theory. For innovation, early reviews find a positive link between innovation and output (Cameron 1998; Nadiri 1993). Econometric studies (measuring innovation through patents) provide further support and suggest countries hosting a larger number and higher-quality patents also experience higher economic growth (Hasan and Tucci 2010; LeBel 2008; Yang 2006).
- Regarding entrepreneurship and growth, early studies suggested new business formation promotes employment growth (Birch 1987; Wennekers and Thurik 1999), increased incomes (Carree and Thurik 2002; Picot et al. 1998) and led to greater TFP growth (Aghion et al. 2004; Baumol 2014). In a review of 57 studies, van Praag and Versloot (2007) found entrepreneurial firms had higher productivity growth and increased innovation.
- Furthermore, risk *aversion* has been linked to lower investment in physical and human capital (Rosenzweig and Stark 1989), wage growth (Shaw 1996), and technology adoption (Liu 2012), thereby reducing growth and economic development potential. If high natural risks lead individuals to become less risk-taking in terms of innovation, education or entrepreneurship, growth and development will suffer.

Table 2.3 Households in developing countries face many shocks (% of respondents reporting type of shock)

Shocks	Afghanistan		India	Laos		Malawi		Peru		Uganda	
	U	R	R	U	R	U	R	U	R	U	R
One or more	16.4	48.9	61.6	34.4	72.1	40.0	66.8	20.7	34.4	29.7	56.2
Two or more	8.7	39.2	23.4	11.9	36.1	12.7	40.4	1.4	1.9	5.6	15.6
Natural disasters (drought, flood)	10.6	42.2	57.3	5.6	36.0	10.4	47.2	2.6	21.5	19.9	52.1
Price shocks	0.2	3.0	–	4.4	4.9	21.1	42.0	–	–	1.7	3.2
Employment shocks	6.4	4.3	–	9.3	3.1	7.7	3.4	6.4	1.5	1.9	0.7
Health shocks (death, illness)	6.9	14.0	30.2	23.2	33.8	10.1	18.0	9.1	8.9	11.8	14.9
Personal and property crime	1.8	6.6	0.9	5.8	1.9	8.5	8.4	3.2	3.1	6.6	8.7
Family and legal disputes	–	–	1.9	0.0	0.9	1.7	4.3	0.7	0.3	–	–

Note *U* urban, *R* rural

Source World Bank (2013) based on data from household surveys, various years 2005–2011

Gollier's seminal work (Eeckhoudt et al. 1996; Gollier and Pratt 1996; Gollier and Schlee 2006) finds, under fairly general conditions, that a higher level of "background risk" (here flood/drought risks) makes individuals less willing to take risks in other domains (e.g. innovation/entrepreneurship). In other words, being exposed to one risk increases an individual's risk aversion regarding other categories of risk. These results suggest households consider their vulnerability to natural risks like floods and droughts when making other risk-related decisions in other domains—such as creating a business or migrating to a city.

Empirical work finds that higher levels of background risk are associated with increased risk aversion in financial decisions (Guiso and Paiella 2008; Lusk and Coble 2008). More recent literature also finds evidence of risk vulnerability with regard to land reform (Tella et al. 2007), early life financial experiences (Malmendier and Nagel 2011), stock market crises (Guiso et al. 2013), and violent trauma (Callen et al. 2014; Voors et al. 2012).

There are two mechanisms through which an increase in the background risk can lead to high risk aversion and lower investment in growth and development.

- The first is rational: there is a possibility that the two independent risks (one related to disasters, the other to risk-taking in general) will materialise together (Gollier and Pratt 1996). This combined risk—and the non-linearity in the utility function—increases risk aversion because a large income shock changes not just an individual's location on the utility function but also the shape of that function (Cassar et al. 2015).
- The second mechanism is behavioural. A shock such as a flood can lead to an overestimation in an individual's perceived likelihood of future natural shocks occurring (Cameron and Shah 2015). Emotional responses can lead individuals to have greater fear of any negative event, reducing risk-taking (Cassar et al. 2015). Consequences, either real or perceived, from multiple shocks occurring in close proximity or simultaneously can be devastating.

The importance of past events on risk aversion is documented in a number of countries, including Bangladesh, Indonesia, Nicaragua and Peru.

Bangladesh. Bangladesh is particularly at risk of coastal flooding and cyclones. Ahsan (2014) examines risk preferences in three coastal communities in Bagerhat, a district in southwest Bangladesh, which regularly experiences cyclones. Socio-economically, the communities studied are heavily reliant on aquaculture and agriculture and are low in income, with average household annual income from farming reported at $1400. Through experiments, risk preferences were investigated and compared with exposure to cyclone. The author found that, on average, non-cyclone-affected subjects bet more in a risk game than subjects who had been affected by cyclones.

Indonesia. East Java, Indonesia, has a population of 37 million and is particularly prone to natural disasters—with floods and earthquakes posing the largest risks. Cameron and Shah (2015) examine whether recent experience of floods and earthquakes affects the level of background risk and risk-taking within the region.

In October 2008, the authors ran a series of experimental games in a random sample of 1550 individuals across 120 villages and found individuals in villages that had suffered a flood/earthquake in the previous three years exhibited higher levels of risk aversion compared with individuals in villages that had not experienced a disaster (41 % decrease in probability of making a risky choice in the experiment).

A year later, the authors conducted a survey asking households to report the probability (or likelihood) that a flood and/or earthquake would occur in their village the following year. For floods (but not earthquakes), individuals who had experienced an event were significantly more likely to report a higher probability of flood in the following year (43 %) compared with those who had not experienced a flood (12 %). Given the true probability of around 3 %, the findings suggest households with recent flood experience over-weight the probability that a future flood occurs. The same is true with severity: those who had experienced a flood also perceived that future floods would be worse. These findings suggest individuals with recent experience perceive the world to be a riskier place; the authors suggest this causes individuals to take fewer risks. Evidence is further provided that behaviour in experiments is correlated with "real-life" risk-taking such as entrepreneurship.

Nicaragua and Peru. Nicaragua and Peru are two disaster-prone countries in Latin America, at risk of flood, drought and hurricane. In 2007, van den Berg et al. conducted risk experiments on a random sample of 100 individuals across regions within each country (Chinandega in Nicaragua; Ancash, Cajamarca, Piura and Tumbes in Peru). They found past experience of a disaster to have a large and significant effect on risk aversion. Across both samples, comparing individuals who had lost assets with those who had not, those who had lost a home exhibited 30 % higher risk aversion; for those who had lost animals this measure was 50 % and for crops it was 60 % (van den Berg et al. 2009). The authors similarly suggest that such reductions in risk aversion continue in the medium run, two years after a disaster. While the authors do not provide evidence on the mechanism through which risk aversion manifests, one plausible conclusion is the increased perception of background risk.

In Vietnam, Reynaud and Nguyen (2012) found experience of floods to have a significant positive effect on demand for insurance, which may reflect higher levels of risk aversion. Also in Vietnam, Dang (2012), combining historical and contemporary survey data, found that individuals living in villages that frequently experience disaster and those who had recently experienced a shock showed higher levels of risk aversion. Abreha (2007) found similar results of drought experience and risk aversion among farmers in Ethiopia.

However, some studies find the opposite—that exposure to natural disasters can make people more risk-loving. In Louisiana, Eckel et al. (2009) conducted an experimental test on individuals exposed to Hurricane Katrina in September 2005, a month after the storm. They found evacuees to be more risk-loving (less risk-averse) after the storm, although this effect was not observed 10 months later. Various other analyses provide evidence on such a change in perception: Page et al. (2014) present a similar risk-loving effect for households that suffered loss as a

result of the 2011 Australian floods in Brisbane[5]; Hanaoka et al. (2015) exhibit similar findings using panel data from Japanese households after the 2011 earthquake and tsunami, but only for men, who gamble and drink more after the event[6]; Andrabi and Das (2010) found the 2005 earthquake in Pakistan increased risk aversion; and Said et al. (2014) had a similar result for the 2010 flood in Pakistan.

But not all studies confirm the finding that risk preferences change. Bchir and Willinger (2013), in a field experiment of lahar risk in Peru, found no significant difference of risk aversion between exposed and non-exposed households. Becchetti et al. (2012) had a similar result of no significant difference in a sample of 380 Sri Lankan microfinance borrowers. In addition, preliminary findings from an experimental game in Cambodia's Battambang province actual found experience with a natural disaster had a positive and significant impact on the risk behaviour of participants (Fiala 2016). The contradiction cannot be easily explained by different contexts, since studies disagree even in one given location. Cassar et al. (2015), through risk experiments of 334 subjects from Thai villages affected to different degrees by the 2004 event, found individuals hit hardest by the disaster exhibited strong risk aversion four and a half years after the disaster (in 2009). Callen (2011), in an experiment conducted on a sample of 456 wage workers in July 2007, found no evidence that risk preferences changed. One possibility is that the impact of background risk is more complex than a simple increase in risk aversion. For instance, Li et al. (2011) found individuals exposed to earthquake and snowfall risk in China could not simply be described as more risk-seeking, but that individuals gave more weight to low probabilities after the 2008 China earthquake and snowfall event.

2.5 Conclusion and Implications for Policy

Most investments in DRM still rely on cost–benefit analyses that estimate the benefits from a project or action through the value of the asset (and/or human losses) it can prevent. But indirect losses can be as substantial as direct asset losses; and indirect losses can lead to human losses (e.g. through undernourishment and children stunting) that need to be added to direct human losses.

While these costs are difficult to quantify—and perhaps because so—they are typically excluded from cost–benefit analyses. Nonetheless, the benefits of a DRM policy to reduce indirect losses can be large. Some DRM action even reduces only indirect losses—for instance, insurance and social protection cannot do much to

[5]One limitation of this study is that, relative to the household's situation at the time of survey, the risk game presents only gain options.

[6]The authors found evidence that men became more engaged in gambling and drinking if they were more exposed to the Earthquake.

reduce asset losses, but they minimise the welfare impacts of these losses.[7] Welfare losses can also be much higher than asset losses, when considering the distribution of these losses, and especially the impact on the poorest. And the development benefits from better-managed risks—for instance through the ability to take other risks linked to entrepreneurship or innovation—could also be significant. Yet this is also difficult to quantify and include in a cost–benefit analysis. For example, the benefits people gain from settling in risky areas in urban areas are typically not valued.

Put simply, at present, the "benefits" of DRM are understated—in terms of both avoided losses and increased development. Considering these benefits in policy design is critical to better manage risk.

For example, some actions to reduce risk (or prevent risk generation) may be counterproductive. What is really needed is not *risk reduction*—that would try to reduce the amount of risk-taking indiscriminately—but *risk management*—that prevents excessive risk-taking while allowing risk-taking in cases where the benefits (e.g. proximity to job opportunity) are clear.

For instance, policies that prevent all investments in flood zones in developing countries cities may be extremely costly. They would reduce migration to cities, thereby potentially preventing individuals from accessing higher-pay jobs and better services and children's access to education. It would be more efficient to implement more detailed zoning policies that distinguish between different types of investments to allow worthy ones but prevent inappropriate ones (e.g. by making a difference between housing and production units).

Another option is to invest in safe places. Indeed, it can be rational to experience growing disaster losses only if investments in risky locations are "more" productive than investment in safe places. If investments in transports can make it as desirable to invest in safe places, risk could be reduced without reducing economic growth and output. People in at-risk informal settlements in developing country cities settle there because they face a difficult trade-off between living in risky places with good access to jobs and services and living in a safe place without these opportunities. They would settle in a safe place and reduce flood exposure if better transportation infrastructure and options connected safe living areas to urban opportunities. Similarly, manufacturing plants are created in at-risk coastal areas, but they could be installed in safe areas if transport infrastructure made it possible to ship their production at similar costs. In the broad framework this chapter proposes, transportation investments are risk mitigation investments when they connect safe areas to the opportunities and amenities that currently exist in risky areas.

By providing a strong and holistic risk management framework, a country, a region or even a city makes it possible for all actors to take the risks that are desirable, avoiding excessive risk-taking without constraining growth and development. It also makes it possible to deal with the rare but unavoidable cases where a

[7]Note that well-designed insurance schemes can also create a positive incentive to invest in risk mitigation and prevention.

physical hazard is so violent that it exceeds protection capabilities and causes large losses. In other words, the same DRM policy that reduces welfare losses from a disaster can also provide benefits even before a disaster strikes.

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